VI.—*The Correlation of the Animikie and Huronian Rocks of Lake Superior.*

By PETER MCKELLAR.

(Communicated by Dr. Bell, May 25, 1887.)

Having had more than twenty years experience, as a practical geologist, among the rocks of nearly every district on both sides of Lake Superior, I may be allowed to offer to the Royal Society the results of my studies of the relations which the different formations of these regions bear to one another. A want of agreement has lately arisen among geologists, as to the equivalency, or otherwise, of the Animikie and the Huronian series of this part of the Dominion, and I propose to confine my remarks chiefly to an elucidation of this problem. I think I am in possession of sufficient facts to set at rest any question as to their mutual relations. The term "Huronian" was first applied by Logan and Murray to a set of metamorphic and igneous rocks north of Lake Huron, and the name was soon extended to rocks, similar to the majority of these, on Lake Superior. Sir William Logan also called the Huronian, the "Lower Copper-Bearing Rocks," and the series of which the Animikie forms the lower part, the "Upper Copper-Bearing Rocks" of Lake Superior. What is considered to be the equivalent of the upper division of this latter series on the south shore of the lake was afterwards called the "Keweenian" formation by the United States Geologists, the name being derived from Keweenaw or Kewaiwana Point. Logan's names—Lower and Upper groups of the Upper Copper-Bearing Rocks of Lake Superior—were found to be inconveniently long for constant use, and Dr. Bell proposed to call the whole series the "Nipigon" formation, it being extensively developed around Nipigon Lake and the Bay of the same name on Lake Superior. The lower and upper groups of the Nipigon (or Upper Copper-Bearing) formation appeared, from Dr. Bell's descriptions, to be unconformable to one another, and Dr. T. S. Hunt, at the suggestion of the writer, proposed the name "Animikie" for the lower portion—*Animikie* being the Outchipwai name for "thunder," the formation being well developed around Thunder Bay. The name "Nipigon" would then be restricted to the upper division. The sandstones of Sault Ste. Marie are generally conceded to be newer than any of the formations referred to, although their relations to some of them have not yet been very satisfactorily demonstrated. According to the Canadian geologists, we have therefore, on Lake Superior, the following sets of rocks, in descending order:—

1. The Sault Ste. Marie sandstones, resting apparently unconformably on the Keweenian.
2. The Nipigon formation, equivalent, at least in part, to the Keweenian.
3. The Animikie formation, unconformable to both the Nipigon above and the Huronian below.
4. The Huronian system.

Mr Kellar assumes That the original Hur. is indivisible and argues That the grunschist part is lithologically like that of Thunder Bay which Lies unconformably below the Animikie which is hence Post Huronian

5. The Laurentian system.

Although it is not my intention in the present paper to discuss the question of the relations of the Laurentian and Huronian systems, I may remark, in passing, that these formations are folded together and appear conformable, yet it is quite probable that unconformabilities do exist within this great body of rocks; of which I have noticed apparent indications in several places as, for instance, south-east of Wabigoon Lake, south of Owl Lake, and in the vicinity of the Little Pic River, etc.

The Huronian rocks of the different areas north of the great lakes differ more or less from one another, both as to the presence or absence of some of their lithological constituents and in the relative volumes or proportions of certain kinds of rocks which may be present; but in the main, the general lithological difference betwen these areas may be considered as of degree and not of kind. No good reason has yet been shown for considering any of them as entitled to a separate classification. To attempt to separate them in the present state of our knowledge, would only lead to confusion. The so-called "Typical Huronian of Lake Huron," contains the same kinds of rocks as the "Huronian areas" of Lake Superior, although the quartzites are in relatively larger volume, and possibly part of the former series may prove to be a little newer than most of the latter.

If the Lake Huron quartzites and their associated rocks could be shown to belong to a formation distinct from all the rest of the rocks which have been classified as Huronian, it might then become difficult to prove their chronological relation to the Animikie formation. Stratigraphy would give but little aid in ascertaining their relative positions, if their equivalency with the Huronian schists of Lake Superior were in doubt. But I believe that almost all geologists are agreed, Prof. Irving among the number, that they belong to the same system. The somewhat lower angles of dip than the average, in part of the Lake Huron region, and the relatively large development of the quartzites, are the circumstances which have caused doubts in the minds of some, who have but limited personal knowledge of the Huronian system, as to their equivalency with the rocks of this age on Lake Superior, which are generally more schistose. But many other examples could be given of low dips in admitted Huronian regions. Again, the quartzites of Lake Huron are conformably associated with great volumes of crystalline schists, apparently identical with those of Lake Superior. The white and grey quartzites, with jasper pebbles of the former region, are also found on the east shore of Lake Superior, and quartzites of different shades are met with in the Huronian bands north of Michipicoten, at Red Lake (to the north of Lake of the Woods) and elsewhere. Dr. Bell has shown that they exist in great force among rocks of the ordinary Huronian types on the north-west coast of Hudson Bay. My personal knowledge of the rocks of Lake Huron is not so complete as of those of Lake Superior; but from the descriptions of Sir William Logan and others, and from what I have myself seen of the Lake Huron strata, the greenstones and schists of the formation there appear to me to be precisely the same in character as their supposed equivalents on Lake Superior and not in the least like the rocks of the Animikie formation. Even the veinstones of the former region are markedly of the Lake Superior Huronian type, and quite different from those of the Animikie series. My impression is that the original Huronian of Lake Huron can never be shown to be equivalent to the Animikie, any more than can the Huronian of Lake Superior. They must either be classified with the last mentioned or as an intermediate formation.

In regard to the Lake Superior region, it seems to me an easy matter to prove the unconformability of the Animikie formation with the Huronian system, as laid down by Dr. Bell, and with the folded schists of Prof. Irving. The latter gentleman, in his interesting and excellent report on the Archæan formations of the North-western States for 1885, admits that the folded schists of the Marquette and Menominee districts, as well as those of the north shore of Lake Superior, or a great part of them, are Huronian. He then tries to show that they are the equivalents of the Animikie formation. He states (p. 206) in reference to the Lake Superior Huronian of Dr. Bell :—

"Accepting, for the time, some of them as Huronian, we are immediately confronted with a structural problem of a good deal of difficulty, i.e. the relation of these folded schists to the unfolded Animikie series. Generally, as the Animikie series is traced towards its northern border, it is found to lie against a belt of granite and gneiss. This is so along the shore of Thunder Bay and thence westward to Gunflint Lake, is true again at the Mesabi Range and Pokegoma Falls district, in Minnesota. North of this belt of granite again come the belts of folded schists. The appearance thus presented is at first sight one of general unconformity between the flat-lying Animikie and an older series, including the gneiss and folded schists. But a close study of the folded schists indicates, as has already been shown by Bell, Chester, Winchell, and myself, much lithological similarity between portions of them and the Animikie series, so that a different structural hypothesis at once presents itself to the mind. This is the one that I have elsewhere illustrated and explained. The hypothesis is, briefly, that the Animikie rocks were once continuous with the folded schists to the north of them, and that they are now separated, merely because of the erosion of the crowns of the folds between them, the close folding of the folded schists being supposed on this view to have been produced concomitantly with the broad, simpler bend which forms the trough of Lake Superior. On this hypothesis, the unfolded schists of the north shore are compared with the unfolded Penokee of the south shore, and the folded schists of the national boundary with the folded schists of the Marquette and Menominee region. All are supposed to represent a great sheet of Huronian deposit, once continuously spread upon a floor of far older gneisses and schists which has since been brought to view by folding and denudation."

It appears from this, as from his whole report, that the professor rests his hypothesis mainly upon the lithological similarity of portions of the two formations to one another and it is not claimed, I believe, anywhere, that stratigraphical structure favours it, but decidedly the contrary. Yet, in the case of contiguous formations like these, stratigraphical evidence is the strongest that can be produced; and, in the present one, as I shall endeavor to show further on, it is clear and decisive against the equivalency of the two formations. It is true that he shows, in regard to the Kingfisher and Knife Lakes districts, that Prof. Winchell saw appearances that indicated a transition of the Animikie flat beds to the folded schists, and that the extensive examination of the same locality by the Assistant Geologist, Chauvenet, showed a correspondence. Irving says (p. 207): "His work thus far, as also the results of our microscopic study of the specimens gathered, have tended to show that the Knife Lake schists are actually the Animikie slates in a folded condition." If so, they must have been folded by local agencies, and I feel confident that they can have no unbroken connection with the folded schists of the Huronian system. I have not been in the locality referred to, but a little to the east I have exam-

ined the Animikie beds on the south side and the Huronian folded schists on the north side of the Saganaga Lake granite. This belt of folded schists is about six miles in width extending to the other side of Saganaganse Lake, where fifteen miles, or so, of gneiss and granite come in, separating this belt from the Jackfish Lake Huronian belt. The flat Animikie beds on the one side, and the Huronian folded schists on the other, of the Saganaga granite are as distinctly different in aspect, and in the strata composing them, as where they are separated by a hundred miles. I cannot believe it possible that there can be a transition from the one to the other.

Lithological Features.—In regard to the lithological features, I consider the two formations distinctly different, as much so as could be expected of two partially metamorphosed series of rocks. The Huronian are much more altered than the Animikie. Not only are the sedimentary portions of the formations widely different, but also the eruptive masses associated with each. The only eruptive rock found with the Animikie beds is a dark-grey crystalline trap; which, in one of the thin beds east of the Thunder Bay Mine, is porphyritic, but I have nowhere else noticed this character. This trap is never seen, to my knowledge, within the Huronian rocks, except in the form of fissure dykes. This statement may be doubted, but I feel confident of its correctness in as far as the north shore of Lake Superior is concerned, but I do not maintain that similar eruptive trap may not have appeared during the Keweenian period. With the Huronian rocks, granite, syenite, and different kinds of greenstones are often associated. The Animikie trap beds, like the trap dykes, often alter the strata next below them. In regard to the sedimentary portions, the clay slates of the Animikie are generally black, passing into grey, arenaceous slate. They show a lamellar thin and thick cleavage or rather bedding, and never exhibit the transverse or true slaty cleavage of the Huronian slates. The clay slates of the Huronian are rarely, if ever, black in color, except in the case of an occasional thin stratum of plumbaginous or carbonaceous schist twenty to fifty feet wide. This schist may be seen on Location 14 M. east of Steel River; it is widely different from the black slates of the Animikie. The Animikie clay-stones are often micaceous, the mica showing in silvery-looking scales. In the vicinity of the silver mines, east of Whitefish Lake, and again at Sawyer's Bay, Thunder Cape, and many other places, the scales are small and sparcely distributed over the partings. In other places they are from one quarter to half an inch in diameter and plentiful, as for instance, in the mountain-face, east of Blende Lake in McTavish Township. Here the black, coarse and fine slaty argillites are largely developped, underneath the Nipigon or Keweenian sandstones. In all these slates the mica is fragmental or derived from another source, while in the Huronian rocks it has been crystallised in place. Another marked characteristic of the Animikie black clay-slates is the occurrence through some of them of irregularly distributed peculiar concretions, described by Sir William Logan and others. These concretions consist of hard, argillaceous, grey masses, generally shaped like a Scotch curling stone, and they are embedded in the black cleavable slates, and there concretions remain solid after the enclosing dark slate has been denuded away. Their size varies from that of an egg to a diameter of several feet, and they are, I believe, peculiar to this formation, never occurring, to my knowledge, in the Huronian schists. They can be seen in many places, as at Silver Mountain, Rabbit Mountain, Porcupine and Beaver

Silver Mines, along Kaministiquia River below Kakabeka Falls, at the Pays Plat Islands in Nipigon Bay and other places.

The Animikie cherts and jaspers, black, red and green, are to a great extent characterised by a peculiar internal oolitic structure, such as I have not seen within the Huronian rocks. I have noticed this feature along the strike of the formation for over one hundred miles, or from Silver Lake to Gunflint Lake.

Again, none of the chloritic, talcoid, actinolitic, micaceous, or dioritic schists, that are so plentiful in the Huronian folded schists, are found among the Animikie beds; nor are any of the obscure conglomerates, so plentifully developed throughout, and so characteristic of, the Huronian of Lake Superior, to be seen in the Animikie. These conglomerates or agglomerates, which are made up of oblong or lenticular masses of various sizes, from a few inches up to twenty feet and more in length, are generally arranged parallel with the bedding. Usually they are thickly packed, and show a gradual transition from the massive central nucleus to the more fissile schistose matrix, the latter being also deeper or darker in color, than the former. It is only on weathered, smooth, wet surfaces that they are well seen. They have been described by Logan, Bell, Macfarlane and others, and different theories have been given for their formation.

The rocks of the Animikie group, as a general rule, have a tendency to break at right angles to the bedding, while the Huronian rocks show a strong tendency to break at acute angles into lenticular fragments, characteristic of crystalline schists. The Animikie strata are conspicuously slaty or flaggy, not schistose; and the Huronian rocks are as conspicuously schistose by reason of the development within themselves of leafy minerals. Again, with the exception of the crystalline trap, chert, dolomite and iron ore, the constituent minerals of the remainder or major portion of the Animikie strata are fragmental, and of exotic origin as shown above in the case of the mica in the clay-slate. Those of the Huronian rocks, on the other hand, have been developed in place by metamorphism. The trap, of course, was crystallised from the molten state. The cherts, jaspers, dolomites and iron ores, have probably been chemically formed, as suggested by Prof. Irving and others. In the Huronian folded schists, chlorite, mica, hornblende, etc., in fine grains, are plentifully developed in places, constituting great thicknesses of the different schists characterised by these minerals, while in the Animikie, I believe, none of these minerals are developed within the sedimentary beds, except perhaps in close proximity to eruptive trap. It would appear that the Animikie strata are not sufficiently metamorphosed for the differentiation of these minerals.

The prevailing greenish aspect of the Huronian folded schists seems to be caused by the partial development of a chloritic ingredient as shown by Prof. Irving. When describing (p. 227) some of the typical Huronian strata, he states, "Most all of the kinds, except those that are nearly purely quartzose, have undergone a considerable amount of metasomatic change, the principal result of which has been the production from the feldspars of chloritic ingredients; whence, chiefly, the dark and often greenish hue presented by these rocks." This dark and greenish hue is a prevailing characteristic with the bulk of the Huronian strata, and is entirely absent from the Animikie. This distinguishing feature alone should, I think, be sufficient to separate the two formations, especially as it is so marked, and where only a line, as it were, separates them for some two hundred miles or more along their northern contact or boundary.

STRATIGRAPHICAL STRUCTURE.—In the foregoing pages, I think I have shown that there is a strongly marked lithological difference between the almost horizontal and unaltered Animikie and the folded crystalline Huronian schists of Lake Superior. Now I will endeavor to prove by stratigraphical evidence that the difference is conclusive.

Prof. Irving shows that the Animikie beds on the north shore of Lake Superior and the Penokee-Gogebic beds of the south shore, in Wisconsin and Michigan, belong to the same horizon and that wherever they are exposed, with the exception perhaps of the Knife Lake area, as on the south shore, along their strike for some sixty miles, and on the north shore in the same way, from Thunder Bay, to Mississippi River, a stretch of over two hundred miles, they present a simple flat bedding with a moderate dip, always towards the great basin of Lake Superior; and that their position, as far as known, is always next underneath the Keweenian group, which agrees precisely with the conditions of the latter or overlying group in relation to the Lake Superior synclinal. He shows also that the folded schists of the north shore and those of the Marquette and Menominee districts are the same formation and that they are characterised by irregular, steep, complex cleavage or bedding, conspicuously different from the simple flat bedding of the Animikie rocks, all of which, I think, no one can doubt; at least it agrees completely with my knowledge of the two formations. But when he claims in his hypothesis, that this broad simple trend of the Animikie under the Lake Superior basin remained undisturbed at the time of the steep folding of the Huronian, I cannot agree with him. It seems clear, and I think Prof. Irving's own showing confirms it, that the Animikie and Keweenian strata must have been comparatively level during the building up of the latter formation, which is now seen on both sides of the lake dipping towards each other underneath the Lake Superior basin. Therefore, the sinking of the strata in the middle of the lake must have taken place after the building up of the Keweenian group, and before the deposition of the now flat-lying Sault Ste. Marie sandstones. The once molten matter, which constitutes the bulk of the Keweenian strata, must have presented a tolerably level surface over this vast area, at the time of the solidification. It seems plain that the broad geological downward bend or synclinal that forms the geological basin of Lake Superior, could not have resulted concomitantly with the close folding of the Huronian strata, as inferred by Prof. Irving in his hypothesis. No one, I think, will claim that the folding of the Archæan strata occurred after the building up of the Keweenian group.

I have traversed, in considerable detail, almost all the Huronian folded schist areas lying between Michipicoten and Lake of the Woods. I have seen the Marquette schist-formation and spent a good deal of time in examining the folded schist-belt on the South Range, south of the Keweenian or Native Copper Range lying to the south of Ontonogon, Michigan. I have found the majority of the strata of each of these areas to present strongly the Huronian greenish chloritic aspect previously mentioned. I have also found these strata almost invariably highly inclined or nearly vertical, and associated with gneiss, syenite and granite; often interstratified with and intersected by the latter two, in which relation the Animikie strata are never found.

This belt of chloritic and greenstone schists occupies the greater part, if not the whole of the south half of Town 46 N. in Range 39 and 40 W. These schists stand on edge or are highly inclined, striking eastward across the middle branch of Otonagon River towards

Marquette and westward across the Wisconsin boundary. On the north, they are bounded by coarse granites which occupy the north slope of the range and on the south, in Town 45, they pass into micaceous and hornblendic gneiss that carries gold in the inclosed quarz veins. No doubt these schists are a continuation of the Marquette and Menomenee schists. But I should be greatly surprised if they can be shown to be the continuation of the Penokee-Gogebic flat slates, as would appear by the arguments and the map of Prof. Irving. I mean by the Penokee-Gogebic belt, the Gogebic belt of slates in which the Colby Iron Mine is situated. Before seeing Prof. Irving's report, I was under the impression that the rocks of the Penokee Iron Range were like those of Marquette, and those of the Gogebic Iron Range like the Animikie rocks.

From all the known facts, it seems certain that the Animikie and Keweenian groups together, form the bottom of the great geological basin of Lake Superior, which covers an area of about 30,000 square miles. These strata show a moderately low dip towards the middle of the lake, but become steeper on the south side than they are on the north. They cover nearly the whole bed of Lake Superior, as may be seen by the exposures on the inlands and main shore. From the broad part or middle of the lake—say, from the meridian of Passage Island, they strike inland one both shores, and with a breadth of one hundred and fifty miles, they continue west-south-westward for more than two hundred and fifty miles—or nearly, if not quite to Mississippi River—leaving a tongue of the old rocks, from the west, to penetrate between them to the end of the lake at Duluth, as will be seen by Irving's map. The Archæan rocks, named the "Laurentian gneiss" and "Huronian folded schists," wherever seen on either side of this great basin are almost invariably highly inclined and unconformable to the comparatively undisturbed strata referred to. But, as would naturally be the case, with a basin or depression such as this, the strike of these two sets of strata (though not the angles of the dip) along the sides would be likely to agree very nearly, which is the actual condition presented, as may be seen on the south side along the South and Gogebic Ranges, and on the north side along the line of contact from Thunder Bay westward. This apparent agreement of the strike of the two sets of strata would render it the more difficult to detect unconformability between them, especially as an unstratified member of the Archæan rocks almost invariably presents itself next the flat strata of the Animikie series. These conditions exist in the only portions of the contact examined by Prof. Irving. But from Thunder Bay eastward, this conformability of strike no longer continues, as may be seen north-east of Thunder Bay and at Black and Nipigon Bays, where the flat-lying strata of the great basin referred to make a deep impression northward across the general strike of the nearly vertical folded schists and gneisses. This general want of conformity may be again seen along the north shore, south-eastward and diagonally across the strike of the Archæan rocks, from Nipigon Bay to Sault Ste. Marie. Along this part of the coast, great belts—miles in width—of the Huronian folded schists, standing on edge, strike into the lake towards the flat basin referred to, and presumably they continue underneath the Animikie group. As for instance, the schists of Michipicoten River, Homer Township, Pic and Steel Rivers, Nipigon and Thunder Bays, all of which strike into the flat geological basin referred to.

The Slate Islands are situated ten miles from the shore, opposite to Steel River. These islands are occupied by folded Huronian schists, standing on edge, running east

and west and measuring over five miles across the strike. They are intercepted at the south-west angle of the large island by the unconformable Animikie and Keweenian beds, which occupy the shore for about three quarters of a mile. The Keweenian amygdaloids, traversed by quartz veins, carrying native copper, dip S.S.W. at an angle of 60° to 75° from the horizon. Immediately behind them, the ferruginous cherty beds of the Animikie group are seen dipping in the same direction at an angle of only 40° to 50° to the horizon. There can be no possible doubt about the identity of the Keweenian group at this locality and I do not think I can be mistaken about the Animikie strata. This discovery of the Keweenian rocks, and also of iron-bearing Huronian schists in the vicinity, was made in 1870 when I was examining the Islands for the Geological Survey, under instructions from Dr. Bell. A year or two afterwards, I examined the Keweenian veins for native copper and found it. Then, when exploring inland the Huronian hematite-bearing schists above mentioned, I noticed a change of dip in the strata, and upon further examination I was greatly surprised to find them to be what I considered the undoubted Animikie slates. I traced them across the strike to the Keweenian beds, which lie in front, and along the shore, the contact being in the line of a fault occupied by a ferruginous trap dyke.

At the east end of Nipigon Bay, the folded schists standing on edge and associated with granite, strike westward into the bay, and they must run directly under the flat Animikie and Keweenian beds that occupy the entire width of the Bay. The latter group continue north for a hundred miles or so into the Lake Nipigon basin. The Animikie beds form a number of islands in the bay, such as those in Pays Plat Bay, and they appear in flat patches on the north shore opposite the east end of Copper Island. Here the Animikie beds are always in positions apparently conformable with and below the Keweenian beds, and in unconformable positions over the Archæan rocks. Further north, the lower beds of the Keweenian group, consisting of sandstones and marls, are found resting on the old rocks without the interposition of the Animikie. In other places, further back, higher members, consisting of the trappean beds only, overlie the old rocks—the marls, and sandstoues, as well as the Animikie strata, being wanting. It would appear that the lower members of these horizontal beds were cut off by the rising of the Archæan floor upon which they were deposited.

To the west of the northern portion of Black Bay, the Keweenian beds extend back or westward ten or twelve miles, with great geological gaps or openings eroded through them down to the Archæan rocks. The latter consist of coarse granitic gneiss with a belt of the green Huronian chloritic, dioritic and fine micaceous schists. I did not see the southern boundary of this belt, but at the outer basin it is three quarters of a mile or more in width; across the strike, and four or five miles further west, at the south end of Wolf Lake, it is only about 1,800 feet wide, with an apparent unconformity on the south side against a coarse granitic rock. These gneisses and schists dip nearly vertically and strike eastward through the gaps or basins above referred to and underneath the flat-lying Keweenian beds. They must, I think, continue eastward across Black and Nipigon Bays, underneath the two flat-lying groups, i.e. the Keewenian and Animikie, and they are no doubt the same as those which appear on the shore to the east of the latter bay. At the outer basin, eight to ten miles from the bay, the rough and uneven surface of the old rocks has attained an elevation above Lake Superior of from 700

to 800 feet. Here, resting upon it, are to be seen only the trappean beds of the Keweenian group, with a low dip east-south-eastward. In the next basin, five to seven miles from the bay, the indurated marls and sandstone beds of the Keweenian group appear under the trappean beds.

Low down, within two or three miles of the bay and about three to four miles south of Wolf River, I saw black-looking flat slates, which I think must be Animikie. I have not been in that locality for years and would not be sure of this point. If Animikie, it would be interesting to trace out the contact with the Keweenian beds. Within these basins and all around this locality, the folded schists, the granites and the gneisses stand vertically or nearly so, and must have been eroded and planed down to a great depth before the deposition of the overlying flat beds, whether the verticality of the strata was caused by folding or by faulting.

Again, in McTavish Township in the vicinity of Enterprise Mine, the old rock foundation, in the form of islands, protrudes through the flat-lying sandstones and marls of the Keweenian group. In similar manner the green Huronian strata protrude through the flat-lying Animikie beds in the vicinity of Blende Lake, near the foot of Thunder Bay, and at other places.

The 3 *A* Silver Mine in McGregor Township, is in the Huronian greenstone-schists formation, and the Silver Harbour Mine in the flat Animikie slates, both locations adjoining. The line of contact of the two formations is covered, but on approaching it, they show no change in their regular dips, which are almost at right angles to one another. Again I could see no tendency to a transition in character—the one showing its Animikie peculiarities and the other the Huronian aspect, as distinctly as when these rocks occur at great distances apart. On the shore of Thunder Bay to the west, between Silver Harbour and Wild Goose Point, I remember distinctly seeing undisturbed patches of the original smooth surface or floor, upon which the Animikie beds were deposited over the nearly vertical Huronian green chloritic and dioritic schists. Some flat Animikie slate was still fast *in situ* at these places. The lower layer consisted of a thin indurated matrix, thickly packed with small pebbles, mostly of white quartz. The vertical schists referred to strike into the bay directly under the Animikie beds. Again further west along the line of contact of the two formations about two miles and a half to the north-west of *T* Harbour, on Location No. 2, the flat Animikie slates are seen in place, filling indentures in the highly inclined green Huronian strata.

At the Duncan (formerly called the Shuniah) Mine two or three miles north-east of Port Arthur, the rocks at the surface consist of the flat-lying, unaltered, Animikie black slates, etc., with the nearly vertical Huronian strata underlying them at a depth of about five hundred feet, while the surface-contact of the two formations lies to the north about one mile from the works. The shaft-sinking, and the deep borings made at this mine with the diamond drill, actually afforded direct proof that the horizontal and unaltered shales, etc., rest immediately on Huronian syenite and on the upturned and denuded edges of the crystalline schists of this series.

The folded schists with associated granites and gneisses are highly inclined or vertical, in the vicinity of Thunder Bay, as is the case with them generally; while the Animikie beds, on the north shore, are, with rare exceptions, flat or slightly inclined. We find patches or outliers of the Animikie beds in their usual flat position, resting on

the old rocks, sometimes half a mile or more from the general line of contact, as, for example, behind Amethyst Harbour.

Near the foot of Thunder Bay, the line of contact of the two formations trends northward across the strike of the Huronian green schists to the granite range lying about five miles back from the bay. Along this line, the two formations are dovetailed into one another for miles. In some cases, the dovetailing is caused by faulting, as for example, along the Blende Lake vein, and along the great Silver Lake fault. The latter causes the slightly-inclined Animikie beds to overlap the vertical Huronian strata on the north side of the fault, for a distance of three miles or more. The overlying Keweenian beds of sandstone and marl overlap the Huronian crystalline schists for over a mile. The conglomerate bed at the base of the Keweenian group is well exposed on the north side of the fault in the cutting on the Canadian Pacific Railway near the west end of Loon Lake, while on the south side, the same bed is exposed east ef the Silver Lake Iron Mine, within fifteen or twenty chains of Silver Lake.

Contact of the Animikie and Keweenian Formations.—Geologists have expressed different views as to the correlation of these formations. I shall here give a few facts relating to this question, which have come under my own observation. I have, in one instance, traced the contact of the Keweenian with the Animikie, which is exposed at intervals, from Lake Superior, near Silver Islet, to the great Silver Lake fault in McTavish Township, a distance of about twenty miles. It starts from the water-level, a little east of Silver Islet, and winds around to Sawyer's Bay; thence, northward, along the west-facing escarpment to the fault above mentioned, at a point about fifteen or twenty chains west of Silver Lake. Here the line of contact has attained an elevation of probably five hundred feet above Lake Superior. All along, it shows a bed of coarse conglomerate, becoming coarser to the north and varying in thickness from a foot to thirty feet or more, and lying between the gritty white sandstones of the Keweenian and the underlying and much more altered strata of the Animikie group. The two formations, which are apparently conformable, dip at a low angle east-south-eastward. There seems to be a dislocation along the foot of the escarpment, extending probably into Thunder Bay, which has brought the lower members of the Animikie group on the west side against the clay-slates on the east side. The black clay-slates, seen underneath the conglomerate bed, for the most of the distance thence, are replaced at Iron Lake, twenty chains south of the great fault, by soft, grey, thin clay-slates which show a thickness of about seventy feet, underneath the sandstones. It is caused no doubt, by faulting of the lower formation at a point further south, where it is not exposed. Some three or four hundred feet to the north of Iron Lake, a dislocation of Animikie age brings the ferruginous chert and jasper beds into position next underneath the conglomerate and sandstone beds; and they continue in this relation northward to the Silver Lake fault. At the Iron Lake fault, which brings the jasper rocks into the above position against the clay-slates on the south side of the fault, the overlying Keweenian beds continue across uninterruptedly, showing that a large amount of Animikie strata must have been denuded away before the deposition of the Keweenian beds.

About a mile or two south of Iron Lake, I saw places where deep erosions in the black clay-slates were filled in and levelled up to the overlying sandstone with coarse conglo-

merate material. At Sawyer's Bay, the Animikie strata corresponding to those exposed on the south-west side in the high part of Thunder Cape, appear to me to have been denuded away to a depth of nearly 1,000 feet, or to their present level beneath the Keweenian strata on the east side, instead of having been brought into that position by a dislocation as geologists have generally supposed.

In conclusion, I would state that it appears to me that the Laurentian gneisses and the Huronian schists of Lake Superior were together involved in a grand disturbance of the rock-formations, which resulted in a general upturning of the strata, and that there had also been a general levelling down of these rocks before the Animikie age. Again it appears that after the deposition of the Animikie formation, geological changes took place without causing much alteration of level, in the course of which the strata were dislocated in many places and afterwards eroded and levelled down to a considerable extent before the commencement of the Keweenian age; and again, as before stated, that the sinking of the Lake Superior geological basin took place after the building up of the Keweenian group, and before the deposition of the Sault Ste. Marie sandstones. It seems probable, that the sinking of the Lake Superior basin was the only event which separated these two formations.